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FLOOD INSURANCE STUDY

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TOWNSHIP OF HOLLAND, NEW JERSEY
HUNTERDON COUNTY

SEPTEMBER 16, 1980

federal emergency management agency
federal insurance administration

COMMUNITY NUMBER - 340509

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PUBLISHED SEPARATELY:

Flood Insurance Rate Map Index

Flood Insurance Rate Map

FLOOD INSURANCE STUDY
TOWNSHIP OF HOLLAND, NEW JERSEY

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the Township of Holland, Hunterdon County, New Jersey, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert Holland to the regular program of flood insurance by the Federal Insurance Administration (FIA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally-supported studies are based. These criteria take precedence over the minimum federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 24 CFR, 1910.1(d). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgements

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were prepared by the State of New Jersey, Department of Environmental Protection, Division of Water Resources, for the Federal Insurance Administration, under Contract No. H-3959. This work was completed in July 1978. The hydrologic and hydraulic analyses for this study were conducted by Michael Baker, Jr., Inc. under subcontract to the New Jersey Department of Environmental Protection.

1.3 Coordination

The identification of streams for detailed and approximate study was decided upon by representatives of the Township of Holland, the FIA, and the New Jersey Department of Environmental Protection (DEP) at a meeting on May 26, 1976.

A Consultation and Coordination Officer's (CCO) meeting was held on March 22, 1977, with representatives of the Township of Holland, the DEP, and Michael Baker, Jr., Inc., to discuss the areas to be studied and to request information on past flooding and maps of the community.

A legal notice announcing the beginning of the study and stating its objectives was placed in the local newspaper once a week for three consecutive weeks.

Agencies and individuals contacted for coordination of mapping, hydrologic, and hydraulic information during the course of this study were the DEP, the Philadelphia District of the U. S. Army Corps of Engineers (COE), the Delaware River Basin Commission (DRBC), the Trenton and Harrisburg offices of the U. S. Geological Survey (USGS), the National Weather Service, the U. S. Soil Conservation Service (SCS), Township of Holland representatives, and local citizens. The township officials were contacted for information as required throughout the course of the study and were kept informed of progress.

The final CCO meeting was held on May 5, 1980, at which time the results of this study were reviewed by representatives of the Township of Holland, the FIA, the DEP, Michael Baker, Jr., Inc., and interested citizens.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Township of Holland, Hunterdon County, New Jersey. The area of study is shown on the Vicinity Map (Figure 1).

The following streams were studied by detailed methods: the Delaware River for its entire length along the township's western and southern boundaries, a distance of 6.5 miles; the Musconetcong River for its entire length along the township's northern boundary, a distance of 6.3 miles; Milford Creek from the downstream corporate limits to the Spring Garden Road bridge, a distance of 1.7 miles; Tributary No. 1 to Milford Creek from its confluence with Milford Creek to the Spring Garden Road bridge, a distance of 0.4 mile; and Tributary No. 1 to the Delaware River from its mouth upstream to the second Phillips Road bridge, a distance of 1.3 miles. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction for the next five years, through July 1983.

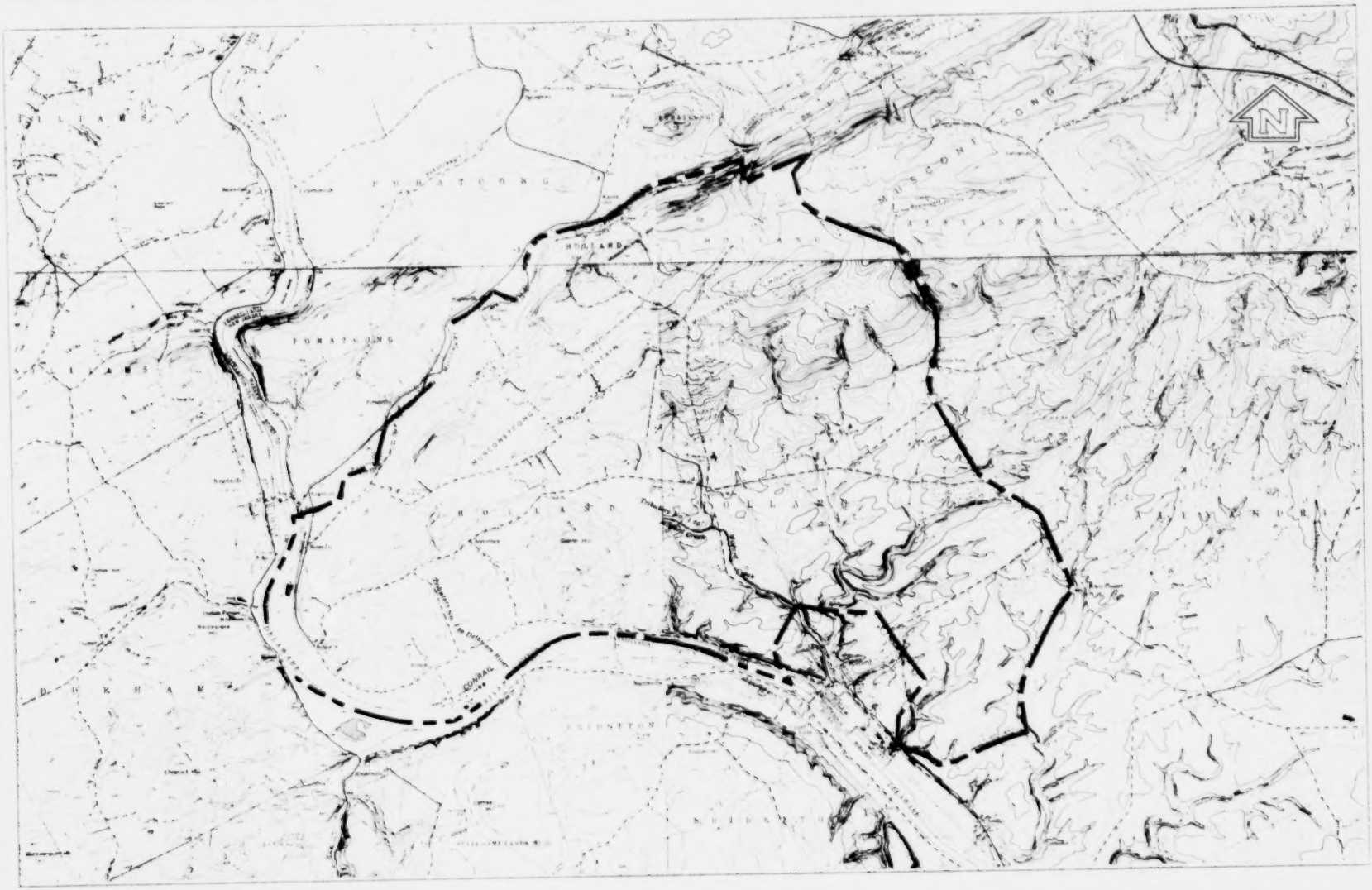


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

APPROXIMATE SCALE
7,000 0 7,000 14,000 21,000 FEET

VICINITY MAP

Approximate methods were used to study the portions of Milford Creek, and Tributary No. 1 to Milford Creek not studied in detail in the Township of Holland, as well as Harihokake Creek and an unnamed tributary to Harihokake Creek. Approximate methods of analysis were used to study those areas having low development potential and minimal flood hazards as identified at the initiation of the study. The scope and methods of study were proposed to and agreed upon by the FIA.

2.2 Community Description

The Township of Holland is located on the western border of central New Jersey in northwestern Hunterdon County, approximately 32 miles northwest of Trenton. Directly across the Delaware River to the west and south lie the Pennsylvania communities of Bridgeton, Nockamixon, Durham, and Riegelsville; the New Jersey Townships of Pohatcong and Bethlehem border Holland on the north; the Township of Alexandria lies to the east and south; and the Borough of Milford borders Holland on the southeast.

Holland, the last township to be formed in Hunterdon County, was created in 1879 when the northwestern section of the Township of Alexandria became a separate entity (Reference 1). A unique situation was created in 1930 with the building of the Gilbert Electric Generating Station in the township. The revenue received by the township from the station was greater than the amount needed for running the local government and school system, and so much money was left over that the township paid all county taxes for its residents. This "tax free" situation existed for at least six years and was a principal reason for development in the township (Reference 2). Today Holland has a total land area of 23.6 square miles and in 1970, a population of 3,587, which represents a 43.8 percent increase over the 1960 population (Reference 3).

The climate in the region is continental and influenced only slightly by the ocean. The area has an average daily maximum temperature of 64 degrees Fahrenheit (°F) and a daily minimum of 42°F, with extremes ranging from 99°F to -7°F over the year. The average annual precipitation is well distributed over the year and totals about 45 inches.

Approximately the southern two-thirds of Holland lies in the Piedmont Plateau region, and the remainder is in the Highlands Division, both of which are part of the Appalachian Province. The Piedmont Plateau, characterized by nearly level lowlands with occasional ridges and low hills, is underlain by sedimentary rocks comprised

mainly of argillite, sandstone, and shale. The Highlands Division is characterized by gentle rolling to steep uplands and is underlain by gneiss, quartzite, and limestone rock (Reference 4). Elevations range from 95 feet at the Delaware River to 960 feet in the northeastern part of the township.

The Delaware River, with a total drainage area of 12,765 square miles is the major waterway feeding the Delaware Bay (Reference 5). With its headwaters in the Catskill Mountains in southeastern New York State, the Delaware River flows southerly along the western and southern border of the Township of Holland. The watershed upstream of Holland consists primarily of open space, agricultural and wooded land away from the main river channels, and areas of highly urbanized development along the river banks. The largest of these is the Allentown-Bethlehem-Easton area along the Lehigh and Delaware Rivers in Pennsylvania. Other smaller urban areas immediately upstream of the township include Phillipsburg, New Jersey and Riegelsville, Pennsylvania.

The Musconetcong River has its headwaters in north-central New Jersey and flows generally southwest to its confluence with the Delaware River opposite Riegelsville, Pennsylvania. The total drainage area at the mouth is approximately 158 square miles. From the mouth upstream for 6.3 miles, the Musconetcong River forms the boundary between the Township of Holland, Hunterdon County, and the Township of Pohatcong, Warren County. Channel elevations along this part of the river increase at an average rate of about 20 feet per mile. Most of its watershed consists of open space, wooded areas, and agricultural lands, with moderate residential and light industrial development near the river's flood plain. Upstream of Holland, the Boroughs of Bloomsbury and Hopatcong are the major centers of development along the river.

Milford Creek begins in the central part of the township and flows generally south into the Borough of Milford, where it empties into the Delaware River. The channel elevations through the township increase at an average rate of 58 feet per mile.

Tributary No. 1 to Milford Creek also begins in the central part of the township and flows southeast to its confluence with Milford Creek. Channel elevations increase about 28 feet along the 1,940-foot length of stream studied in detail.

The watersheds of Milford Creek and Tributary No. 1 to Milford Creek consist of open space, agricultural land, and wooded areas, except for the area near the confluence of the two streams and a small area

in the Milford Creek watershed approximately 1.0 mile upstream of the limit of detailed study. In these two areas there is residential development in the form of lot plans.

Tributary No. 1 to the Delaware River begins in the west-central part of Holland and flows generally south to its confluence with the Delaware River. The watershed consists almost totally of undeveloped open areas, woodlands, and agricultural land with only a few residential dwellings. Channel elevations increase at an average rate of about 95 feet per mile.

Development in the township, even from its earliest days, has been primarily residential and agricultural. The only types of business in the township during its early history were those that catered to the local people, such as sawmills, grist mills, and ferries. Today, business consists mostly of small stores and shops. There are several industrial facilities, including a paper production plant and the Holland Power Plant of the New Jersey Power and Light Company (Reference 6).

2.3 Principal Flood Problems

Flooding has been a continual problem along the Delaware River since settlement of the area in the early part of the 17th century. The Delaware River Basin lies in an area of major storm paths. Although the most severe floods in the past generally resulted from excessive rainfall alone, flooding on the Delaware River in early spring can be even more severe because of moving ice and snowmelt.

Floods of major significance on the Delaware River occurred in October 1903, August 1955 and May 1972. The flood of August 1955 was the most devastating event experienced on the Delaware River. This flood, which had approximately a 150-year recurrence interval, was the result of excessive rainfall from three separate storms which hit the area in early August. According to the gage in Flemington, New Jersey, the nearest official recording station, a total of 15.2 inches of rain fell on the area during the period from August 1 to August 18, culminating with Hurricane Diane (Reference 7). Major damage was done to communities, roads, and bridges along the Delaware River. The small communities of Holland and Mt. Joy suffered heavy residential losses. The Holland Power Plant was put out of production on Friday, August 19, when the floodwaters stood waist-deep inside the plant (Figure 2).

The most recent high water on the Delaware River occurred in June 1973. The flood of June 1972, which resulted from the rainfall of Tropical Storm Agnes, produced severe flooding on the Schuylkill

Figure 2 - Holland Power Plant closed by Delaware River floodwater, August 1955.

River and many otner streams in Pennsylvania, but did not cause major flooding on the Delaware River (References 8 and 9).

Flooding near the mouths of the Musconetcong River and Tributary No. 1 to the Delaware River is primarily a result of backwater from the Delaware River. Flooding on the upper portion of the Musconetcong River in the Township of Holland has not been severe in the past, due to the regulatory effect of numerous dams on the river and to the relatively light development within its flood plain. Shallow property flooding has occurred, but has generally been due to debris blockage behind bridges and other obstructions in the flood plain, which create ponding situations. Flooding on the upper portion of Tributary No. 1 to the Delaware River is primarily due to the steep stream gradient. Scour and erosion problems and shallow property flooding are the major problems on this portion of the river.

Flooding problems along Milford Creek and Tributary No. 1 to Milford Creek have not been extensive in the past. However, with the recent

development of the Spring Mills and Reigel Ridge areas, erosion and alluvium problems, as well as shallow flooding of residences near the flood plains, have occurred.

Figures 3 and 4 show the projected 100- and 500-year flood heights at the Conrail bridge over Mt. Joy Road and at the intersection of Conrail tracks and the entrance to the Holland Power Plant.

Figure 3 - Projected 100- and 500-year flood elevations at the Conrail bridge over Mt. Joy Road.

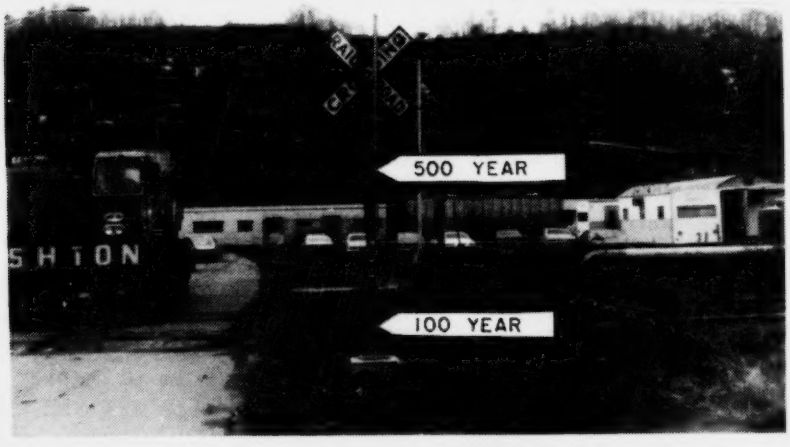


Figure 4 - Projected 100- and 500-year flood elevations at the intersection of Conrail tracks and the entrance to the Holland Power Plant.

2.4 Flood Protection Measures

No flood protection measures to reduce potential flood damage exist in the Township of Holland itself; however, water-supply, power, and flood-control reservoirs outside the township have reduced the probability of damaging floods. Table 1 lists the major regulatory reservoirs and lakes, the drainage areas they control, and the date storage began for the Delaware River Basin upstream of Holland (References 8 and 10).

TABLE 1 - REGULATORY LAKES AND RESERVOIRS UPSTREAM OF TOWNSHIP OF HOLLAND

Name	Stream	Drainage Area	Storage Began
Lake Wallenpaupack	Wallenpaupack Creek	228	November 1925
Prompton Reservoir	West Branch Lackawaxen River	59.6	July 1960
General Edgar Jadwin Reservoir	Dyberry Creek	64.5	October 1959
Francis E. Walter Reservoir	Lehigh River	289	February 1961
Beltzville Lake	Pohopoco Creek	96.3	February 1971
Pepacton Reservoir	East Branch Delaware River	371	September 1954
Swinging Bridge Reservoir	Mongaup River	118	January 1930
Neversink Reservoir	Neversink River	91.8	January 1953
Cannonsville Reservoir	West Branch Delaware River	454	September 1963
Penn Forest Reservoir	Wild Creek	16.5	October 1953
Wild Creek Reservoir	Wild Creek	22.2	January 1941
Lake Hopatcong	Musconetcong River	25.6	1828

TABLE 1 - REGULATORY LAKES AND RESERVOIRS UPSTREAM OF TOWNSHIP OF HOLLAND - continued

Name	Stream	Drainage Area	Storage Began
Toronto Reservoir	Black Lake Creek	23.2	January 1926
Cliff Lake	Black Lake Creek	6.46	January 1939

Completion dates for two proposed reservoirs in the Lehigh River Basin, Aquashicola and Trexler, have not been set; therefore, the effects of these two reservoirs were not considered in this study.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one-percent chance of annual occurrence) in any 50-year period is about 40 percent (four in ten) and, for any 90-year period, the risk increases to about 60 percent (six in ten). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

Flood-frequency analysis procedures developed by the Water Resources Council (WRC) were employed for the Delaware and Musconetcong Rivers (Reference 11). A log-Pearson Type III distribution of annual peak discharges on the stream gages at Trenton and Riegelsville was used to determine the values of the 10-, 50-, 100- and 500-year peak discharges of the Delaware River. Modification of frequency distributions was made to allow for the effects of reservoir regulation.

Discharges for the portion of the Musconetcong River studied in detail were computed from a log-Pearson Type III distribution of annual peak discharges adjusted for regional skew at the stream gages at Bloomsbury and Hackettstown, both in New Jersey.

Flood-frequency analyses for Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to the Delaware River were made by use of a regional regression analysis which considers drainage area, channel slope, surface storage, and the extent of impervious areas in determining the peak discharges for the 10-, 50-, 100- and 500-year floods (Reference 12).

A summary of drainage area-peak discharge relationships for the streams studied by detailed methods is shown in Table 2, "Summary of Discharges."

TABLE 2 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
DELAWARE RIVER					
At confluence of Tohickon Creek	6,328	137,000	230,000	278,000	410,000
MILFORD CREEK					
At downstream corporate limits	3.51	900	1,480	1,840	2,870
At confluence with Tributary No. 1	1.77	540	900	1,130	1,770
TRIBUTARY NO. 1 TO MILFORD CREEK					
At mouth	1.03	300	510	640	1,030

TABLE 2 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
TRIBUTARY NO. 1 TO DELAWARE RIVER					
At mouth	1.94	540	910	1,150	1,840
1,310 feet upstream of River Road	1.63	500	840	1,060	1,690
1,380 feet upstream of Phillips Road	1.14	360	620	790	1,270
MUSCONETCONG RIVER					
At mouth	157.6	3,910	6,600	8,070	12,300
At Mt. Joy Road bridge	156.2	3,880	6,560	8,010	12,230
At Willow Lane bridge	153.9	3,840	6,500	7,930	12,140
At Riegel Paper Company	150.4	3,780	6,420	7,820	12,000

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of these flooding sources.

Cross-sections for the backwater analysis of the Delaware River were field-surveyed by the COE, and additional information was taken from detailed topographic maps (Reference 13).

Valley and structure cross-section data for the backwater analysis along the Musconetcong River were obtained by photogrammetric compilation, from field surveys by the COE and the DEP, and from information extracted from Works Progress Administration drawings (Reference 14).

All cross-sections for Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to the Delaware River were obtained by photogrammetric compilation and were located at close intervals above and below bridges and culverts in order to compute significant backwater effects. All bridge data for Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to the Delaware River were obtained by field survey.

Roughness coefficients (Manning's "n") for these computations were assigned on the basis of field inspection of the flood plain areas,

by comparison with high-water marks, where available, and, for the Delaware River, from previous studies by the COE. The range of Manning's "n" for each stream is listed below.

	Channel	Overbanks
Delaware River	0.032-0.035	0.10
Milford Creek	0.030-0.050	0.12
Tributary No. 1 to Milford Creek	0.045	0.10
Tributary No. 1 to the Delaware River	0.025-0.045	0.08-0.10
Musconetcong River	0.035	0.09

Starting water-surface elevations for the Delaware River were obtained from records of the gage at Trenton, New Jersey. For the Musconetcong River, starting water-surface elevations for all floods were assigned a value of 137.62 feet, which was well below the backwater elevations of all floods on the Delaware River. For Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to the Delaware River, starting water-surface elevations were estimated at the mouths by the slope/area method as outlined in the COE HEC-2 users manual (Reference 15).

Water-surface elevations for floods of the selected recurrence intervals were computed through use of the HEC-2 step-backwater computer program (Reference 16).

Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals. Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway is computed (Section 4.2), selected cross-section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 3).

Flood data for the approximate-study streams were obtained through use of the regional regression analysis described in section 3.1 (Reference 12).

All elevations used in this study are referenced to the National Geodetic Vertical Datum of 1929 (NGVD), formerly referred to as Sea Level Datum of 1929. Locations of the elevation reference marks used in the study are shown on the maps.

The hydraulic analyses for this study are based on the effects of unobstructed flow. The flood elevations shown on the profiles are valid only if hydraulic structures remain unobstructed, and dams and other flood control structures operate properly and do not fail.

Supercritical flow occurs on most of the studied portion of Tributary No. 1 to the Delaware River. This is a rapid flow which is sometimes highly turbulent and usually occurs in steep parts of the stream. Subcritical flow, the more common type, has a relatively low velocity, as it usually occurs on streams with flatter slopes. Except for the reach extending from the mouth to a point approximately 500 feet upstream of the Conrail bridge, and for distances of approximately 500 feet upstream of the River Road bridge and the Phillips Road bridge where the backwater effect created by the bridges reduces the velocities to a subcritical flow situation, flows on all of Tributary No. 1 to the Delaware River are supercritical.

The flow transition between a supercritical and a subcritical region usually involves turbulence, with an accompanying loss of energy. Furthermore, the length of this turbulent transition, called a hydraulic jump, is unpredictable and is different for each flow. It should be noted that hydraulic jumps for small streams usually occur within the channel banks and have little or no effect on the land adjacent to the stream.

According to an accepted engineering analysis involving the velocity and depth of the upstream supercritical sections (Reference 17), the hydraulic jumps that occur during flooding on Tributary No. 1 to the Delaware River are the undular type, which involve relatively small turbulent energy losses and represent somewhat gradual transitions between the supercritical and subcritical regimes. Therefore, a linear assumption between the two flow regimes, as shown on the Flood Profiles, is a reasonable one.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FIA as the base

flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000 with a contour interval of 20 feet (Reference 13). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year boundary has been shown.

The 100-year flood boundaries for the approximate-study streams were delineated on the same topographic maps using data obtained from the regional regression analysis for New Jersey described in section 3.1 (Reference 12).

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 3). Small areas within the flood boundaries may lie above the flood elevations and, therefore, may not be subject to flooding. Owing to limitations of the map scale and lack of detailed topographic data, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood can be carried without substantial increases in flood heights. Minimum standards of the FIA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. However, the State of New Jersey has established criteria limiting the increase in flood heights to 0.2 foot. Thus, floodways having no more than a 0.2-foot surcharge have been delineated for the Musconetcong River, Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to the Delaware River. Since the Delaware River acts as the boundary between the States of New Jersey and Pennsylvania, the floodway delineated for it was determined based upon a surcharge of 1.0 foot, in accordance with FIA

standards for floodways on streams dividing two states. The floodways in this report are presented to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plains. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 3).

As shown on the Flood Boundary and Floodway Map (Exhibit 3), the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The floodways computed for the western side of the Delaware River and for the northern side of the Musconetcong River lie outside the corporate limits of Holland.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point along the Delaware River or more than 0.2 foot at any point along the Musconetcong River, Milford Creek, Tributary No. 1 to Milford Creek, and Tributary No. 1 to the Delaware River. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 5.

Floodwaters from Tributary No. 1 to the Delaware River were found to have hazardous velocities. Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. To provide guidance for encroachment into these areas, a proposed floodway is delineated for that part of the 100-year flood plain that conveys flow.

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "With Floodway" elevations presented in Table 3 for certain downstream cross sections of the Musconetcong River and Tributary No. 1 to the Delaware River are lower than the regulatory flood elevations in that area, which must take into account the 100-year flooding due to backwater from other sources.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Delaware River								
A	2,500[1]	682/345[3]	26,815	10.4	141.7	141.7	142.6	0.9
B	7,800[1]	876/260[3]	25,546	10.9	144.1	144.1	145.1	1.0
C	10,440[1]	930/310[3]	28,298	9.8	146.2	146.2	147.1	0.9
D	13,080[1]	915/500[3]	28,879	9.6	147.5	147.5	148.5	1.0
E	15,720[1]	738/450[3]	24,098	11.5	148.6	148.6	149.6	1.0
F	17,730[1]	784/410[3]	28,018	9.9	150.5	150.5	151.5	1.0
G	19,740[1]	1560/320[3]	41,029	6.8	152.3	152.3	153.2	0.9
H	23,427[1]	1948/380[3]	33,276	8.4	153.0	153.0	153.8	0.8
I	25,989[1]	957/480[3]	29,998	9.3	154.6	154.6	155.4	0.8
J	28,989[1]	859/540[3]	25,533	10.9	155.7	155.7	156.4	0.7
K	30,614[1]	796/420[3]	23,490	11.8	156.1	156.1	156.8	0.7
L	34,020[1]	721/360[3]	24,815	11.2	159.1	159.1	159.8	0.7
Milford Creek								
A	8,138[2]	75	399	5.8	180.7	180.7	180.8	0.1
B	9,132[2]	40	177	10.4	190.3	190.3	190.4	0.1
C	9,863[2]	42	249	7.4	199.7	199.7	199.7	0.0
D	10,624[2]	104	235	7.8	204.3	204.3	204.3	0.0
E	11,019[2]	124	435	4.2	209.5	209.5	209.7	0.2

[1]Feet above corporate limits
[2]Feet above confluence with Delaware River
[3]Width/width within corporate limits

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOODWAY DATA

DELAWARE RIVER AND MILFORD CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Milford Creek (continued)								
F	11,567[1]	189	516	3.6	215.0	215.0	215.0	0.0
G	12,078[1]	204	501	3.7	220.8	220.8	221.0	0.2
H	12,886[1]	279	756	2.4	231.1	231.1	231.2	0.1
I	13,686[1]	305	670	2.7	237.5	237.5	237.7	0.2
J	14,596[1]	281	819	2.2	244.8	244.8	244.9	0.1
K	15,236[1]	223	612	3.0	251.2	251.2	251.4	0.2
L	15,705[1]	122	285	4.0	256.4	256.4	256.5	0.1
M	16,180[1]	115	265	4.3	263.6	263.6	263.8	0.2
N	16,575[1]	110	285	4.0	270.6	270.6	270.8	0.2
Tributary No. 1 to Milford Creek								
A	279[2]	53	115	5.6	254.4	254.4	254.6	0.2
B	887[2]	49	103	6.2	262.3	262.3	262.5	0.2
C	1,351[2]	58	106	6.0	269.5	269.5	269.5	0.0
D	1,760[2]	61	113	5.7	275.4	275.4	275.6	0.2

[1] Feet above confluence with Delaware River
[2] Feet above confluence with Milford Creek

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOODWAY DATA

MILFORD CREEK AND TRIBUTARY NO. 1 TO MILFORD CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Tributary No. 1 to Delaware River								
A	260	57	366	3.1	148.5	129.0[3]	129.2	0.2
B	870	61	328	3.5	148.5	137.8[3]	138.0	0.2
C	1,300	86	153	7.5	148.5	144.6[3]	144.6	0.0
D	1,950	26	62	18.5	155.5	155.5	155.5	0.0
E	2,510	67	193	6.0	166.0	166.0	166.1	0.1
F	3,105	169	237	6.0	173.4	173.4	173.4	0.0
G	3,540	21	51	22.4	176.4	176.4	176.4	0.0
H	4,270	87	243	4.4	191.1	191.1	191.3	0.2
I	4,737	146	186	5.7	197.8	197.8	197.8	0.0
J	5,300	268	163	4.9	207.2	207.2	207.2	0.0
K	5,699	96	110	7.2	215.7	215.7	215.7	0.0
L	6,152	53	68	11.6	224.5	224.5	224.5	0.0
Musconetcong River								
A	139	87/60[2]	847	9.5	159.2	138.6[3]	138.8	0.2
B	1,448	775/50[2]	3,014	2.7	159.2	142.1[3]	142.2	0.1

[1] Feet above confluence with Delaware River
[2] Width/width within corporate limits
[3] Elevations computed without consideration of backwater effects from Delaware River

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOODWAY DATA

TRIBUTARY NO. 1 TO DELAWARE RIVER AND MUSCONETCONG RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Musconetcong River (continued)								
C	2,292	364/30	1,085	7.4	159.2	142.7[3]	142.9	0.2
D	4,050	423/380	1,861	4.3	159.2	149.6[3]	149.6	0.0
E	5,737	736/60	2,261	3.6	159.2	155.6[3]	155.8	0.2
F	7,967	333/250	2,118	3.8	160.3	160.3	160.5	0.2
G	10,082	445/200	2,810	2.9	166.0	166.0	166.2	0.2
H	11,599	401/40	2,262	3.5	167.4	167.4	167.5	0.1
I	13,388	434/245	2,103	3.8	170.2	170.2	170.4	0.2
J	14,941	750/700	3,089	2.6	172.7	172.7	172.9	0.2
K	15,957	306/150	1,479	5.4	173.8	173.8	174.0	0.2
L	18,790	600/61	3,026	2.6	180.8	180.8	180.9	0.1
M	20,902	475/444	1,431	5.5	183.3	183.3	183.5	0.2
N	22,600	419/358	2,406	3.3	187.2	187.2	187.4	0.2
O	27,921	138/68	730	10.9	218.3	218.3	218.3	0.0
P	32,972	165/86	1,026	7.6	256.8	256.8	256.8	0.0

[1] Feet above confluence with Delaware River
[2] Width/width within corporate limits
[3] Elevations computed without consideration of backwater effects from Delaware River

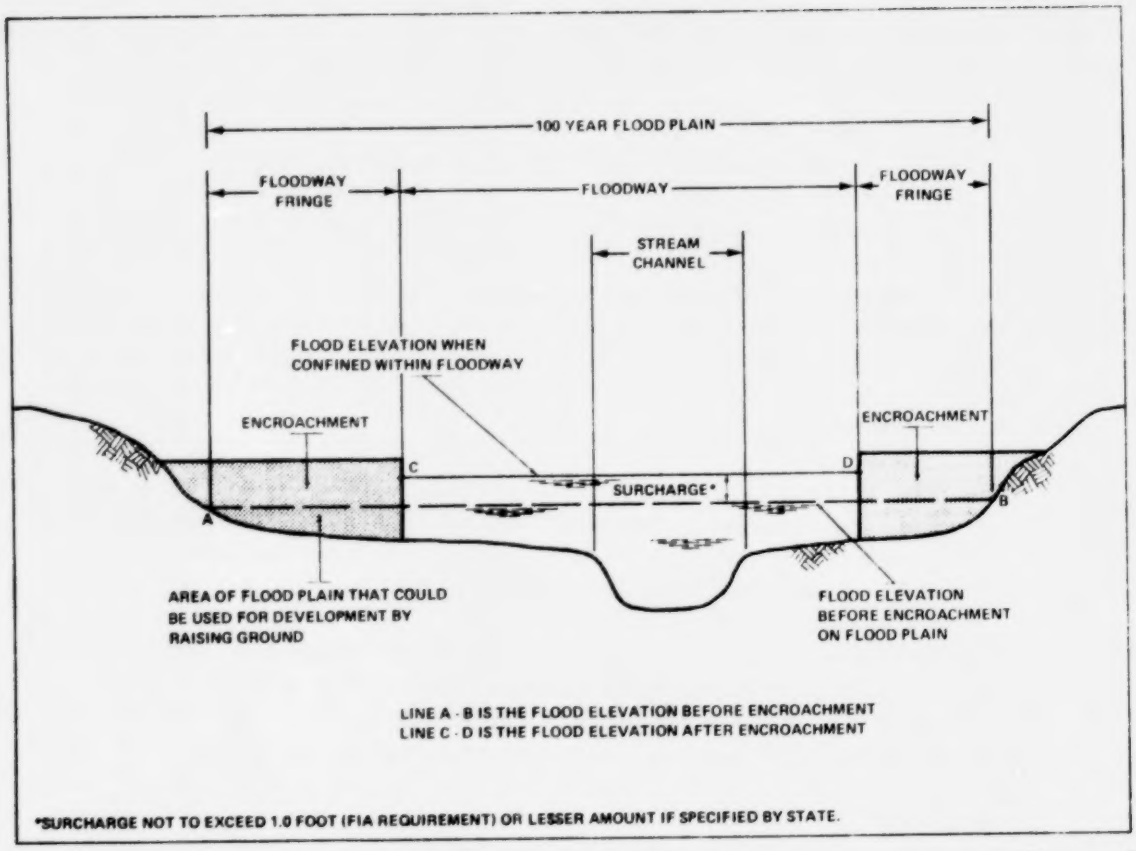
TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOODWAY DATA

MUSCONETCONG RIVER


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FIA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FLOODWAY SCHEMATIC Figure 5

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FIA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source affecting the Township of Holland.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of the Township of Holland are shown on the Flood Profiles (Exhibit 1) and are summarized in the Flood Insurance Zone Data Table (Table 4).

5.2 Flood Hazard Factors

The FHF is the FIA device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the Township of Holland was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zones A1, A2, A3, A4, A5, A16, A18, A23:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHF.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Delaware River							
Reach 1	04, 05	-8.0	-2.3	+5.1	080	A16	Varies
Reach 2	04	-9.2	-2.7	+5.9	090	A18	Varies
Reach 3	01, 04	-12.6	-3.9	+9.4	130	A23	Varies
Milford Creek							
Reach 1	05	-2.0	-0.6	+1.6	020	A4	Varies
Reach 2	05	-1.2	-0.4	+0.9	010	A2	Varies
Tributary No. 1 to Milford Creek							
Reach 1	05	-0.7	-0.2	+0.6	005	A1	Varies
Tributary No. 1 to Delaware River							
Reach 1	01, 04	-1.3	-0.4	+1.6	015	A3	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted average
[3]Rounded to the nearest foot - see map

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOOD INSURANCE ZONE DATA

DELAWARE RIVER, MILFORD CREEK, TRIBUTARY NO. 1 TO MILFORD CREEK AND TRIBUTARY NO. 1 TO DELAWARE RIVER

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Musconetcong River Reach 1	01, 02, 03	-2.6	-0.8	+2.0	025	A5	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted average
[3]Rounded to the nearest foot - see map

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOOD INSURANCE ZONE DATA

MUSCONETCONG RIVER

Zone B: Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 4, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for the flooding sources studied in detail in the township.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the Township of Holland is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FIA.

6.0 OTHER STUDIES

A Flood Plain Information Report on the Delaware River was prepared by the COE in 1967 (Reference 18). That report was a planning document to evaluate the effects of the Tocks Island Dam Project. It did not assign frequencies to the discharges used; therefore, numerical comparisons with this report have not been made.

A flood plain delineation report was published by the DRBC in 1973 (Reference 19). That report was also a planning document and numerical comparisons could not be made with it.

Flood Insurance Studies have been published for several Pennsylvania communities lying across the Delaware River from Holland: the Township of Bridgeton, the Township of Durham, the Township of Nockamixon, and the Borough of Riegelsville (References 20, 21, 22, & 23). Flood

Insurance Studies have also been prepared for the adjacent communities of Milford, Alexandria, and Pohatcong (References 24, 25, and 26). Data used in these studies were coordinated to ensure agreement of results across municipal boundaries.

This study is authoritative for purposes of the Flood Insurance Program, and the data presented here either supersede or are compatible with previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the office of the Insurance and Mitigation Division of the Federal Emergency Management Agency, Regional Director, Region II Office, 90 Church Street, Room 801, New York, New York 10007.

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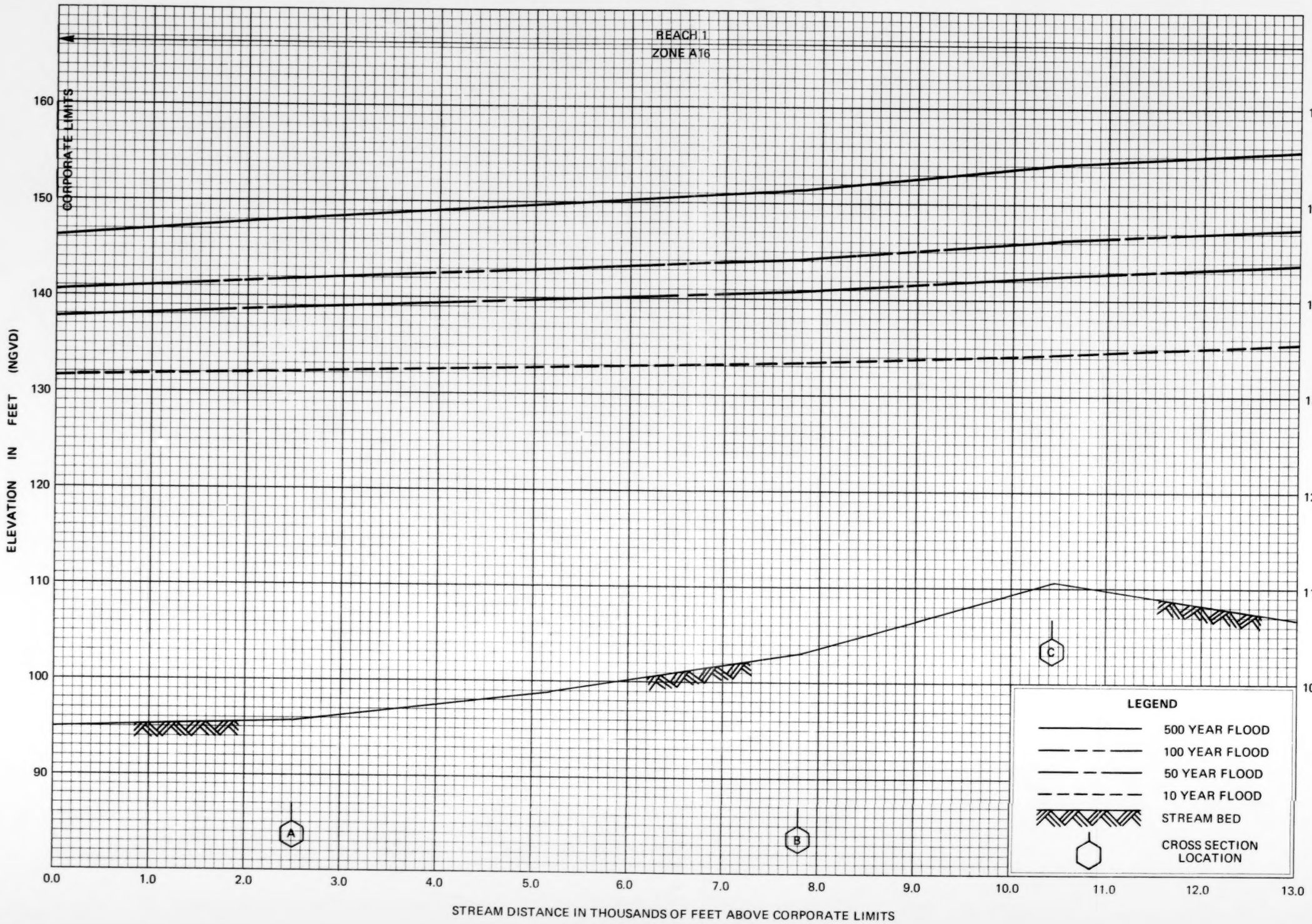

FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

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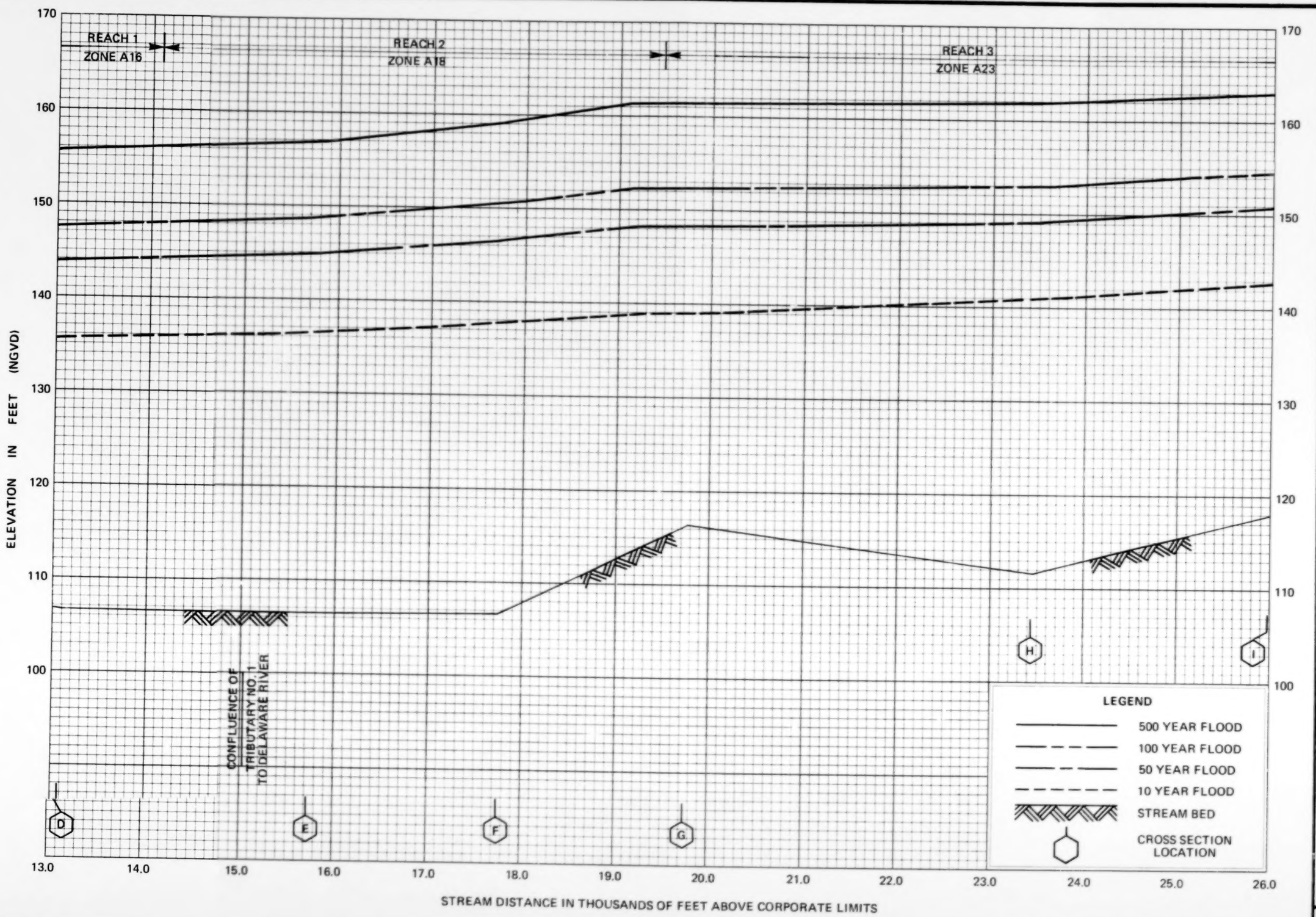

FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

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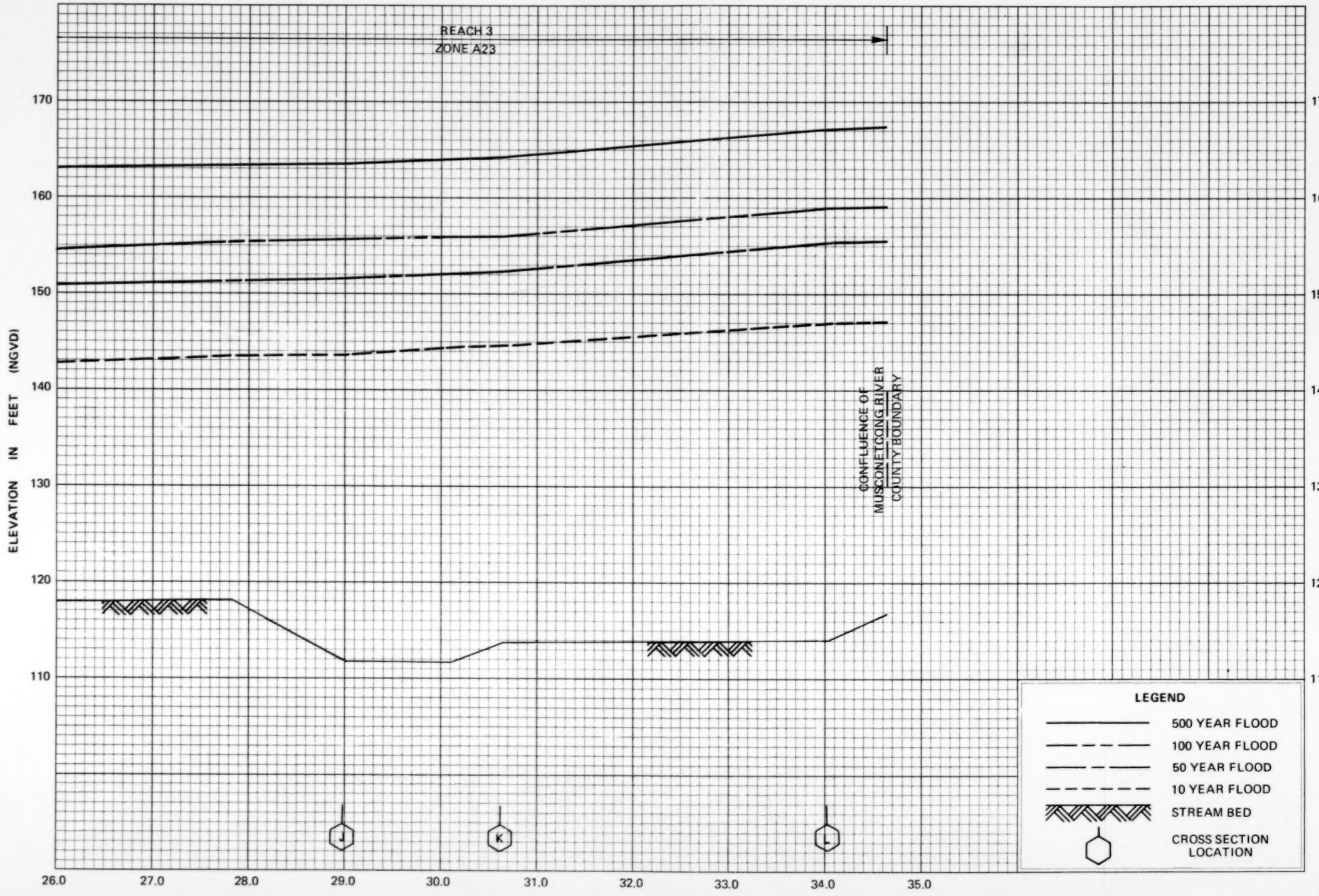

FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

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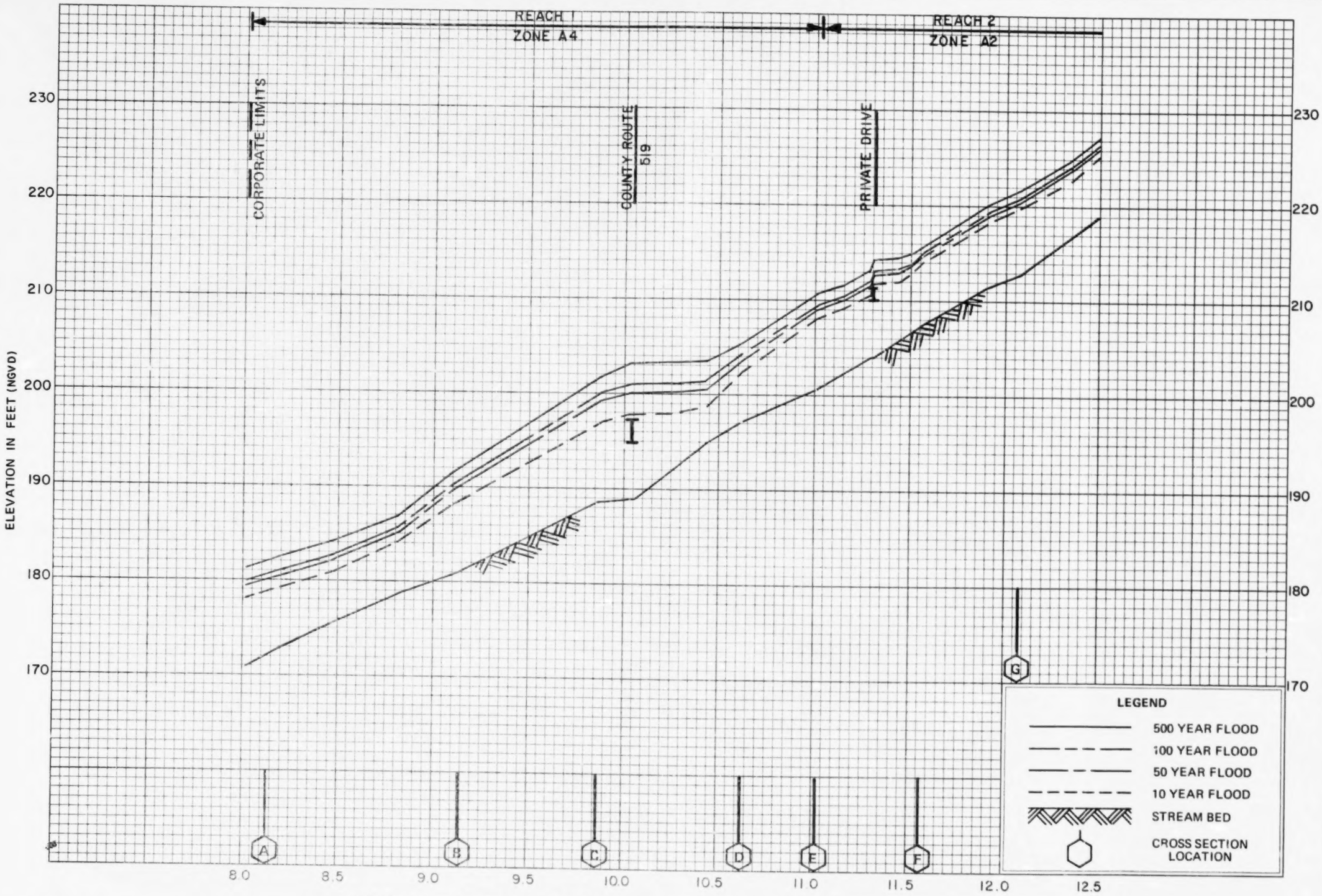

FLOOD PROFILES

MILFORD CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

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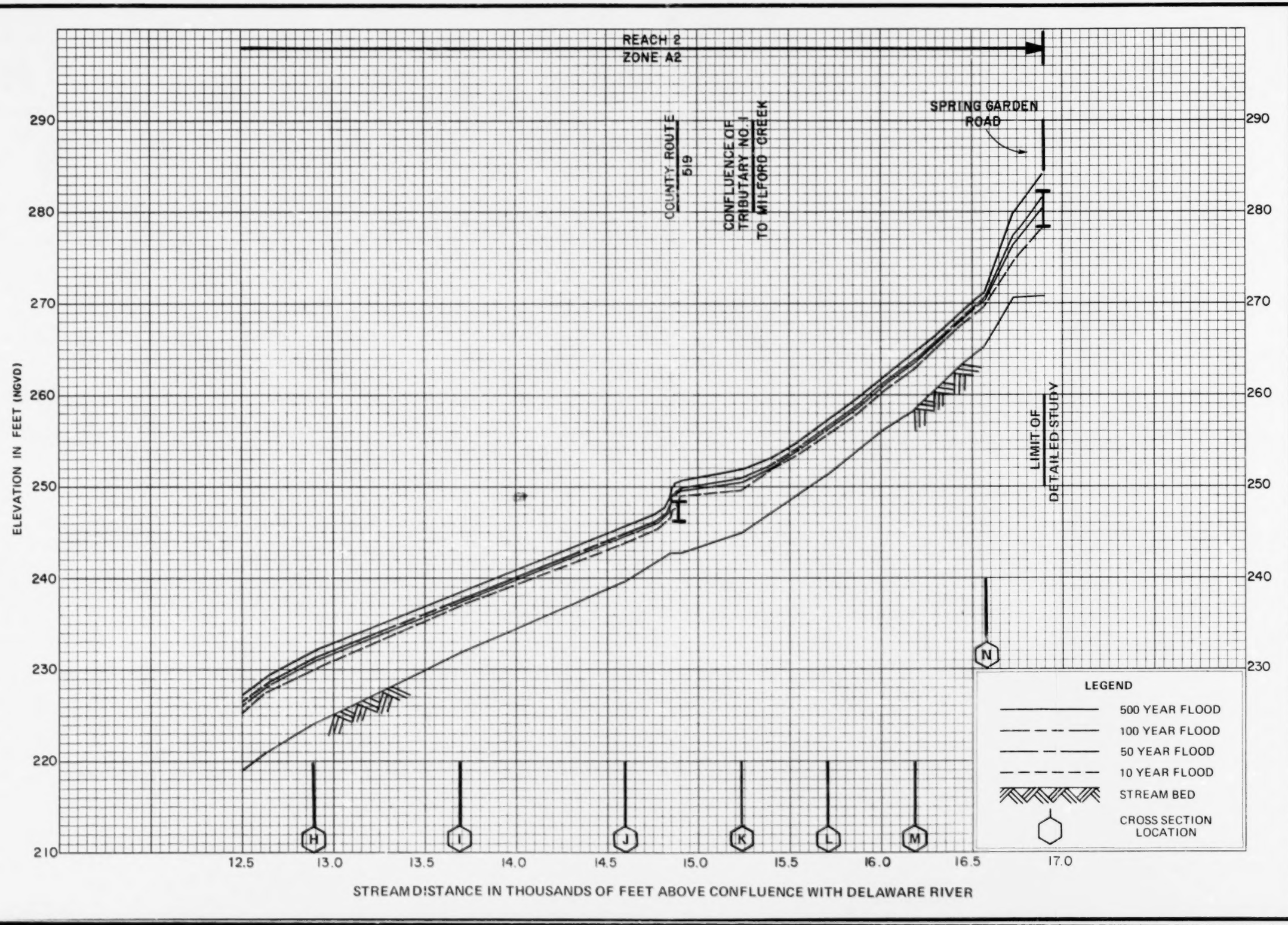

FLOOD PROFILES

MILFORD CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

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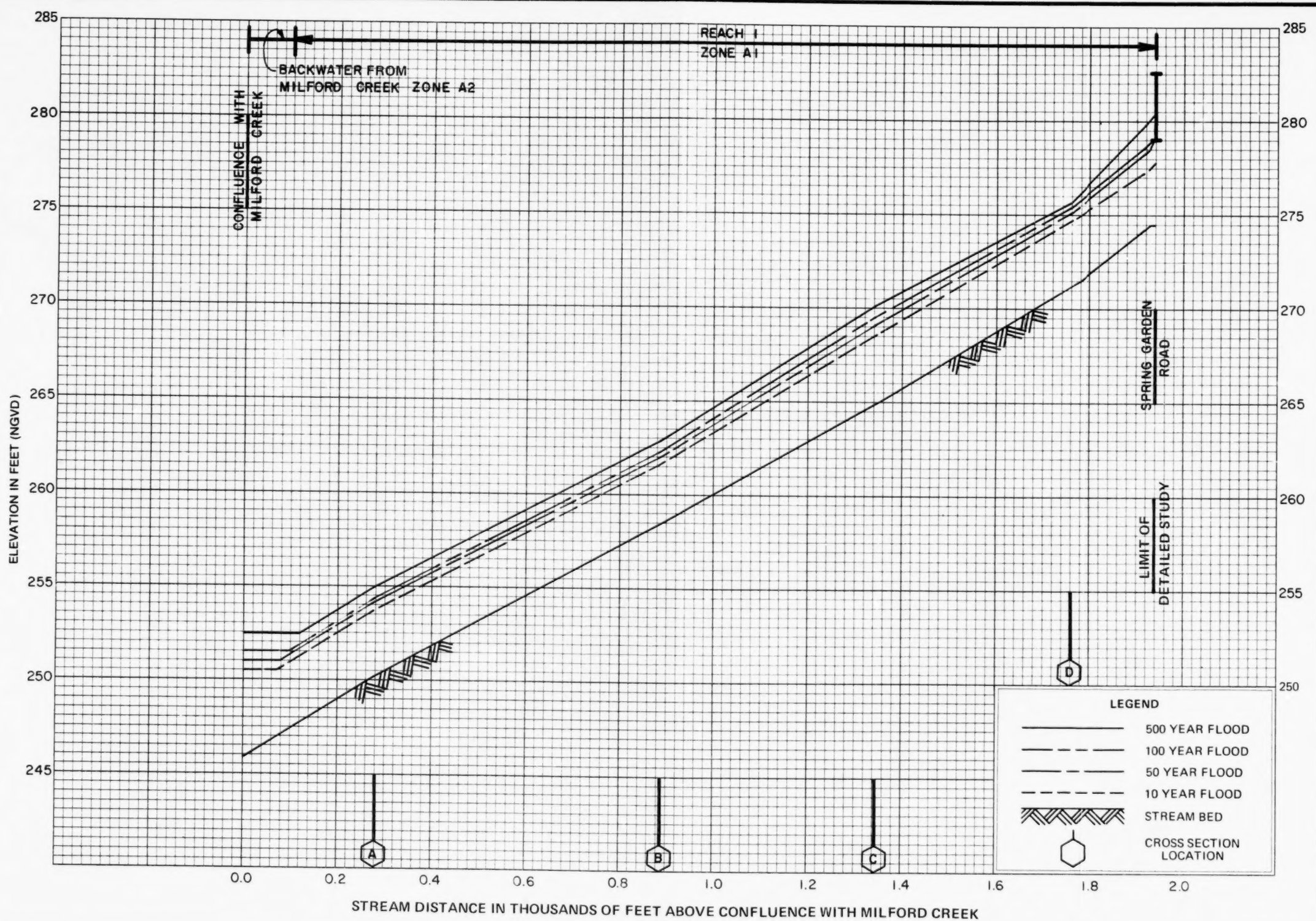

FLOOD PROFILES

TRIBUTARY NO. 1 TO MILFORD CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

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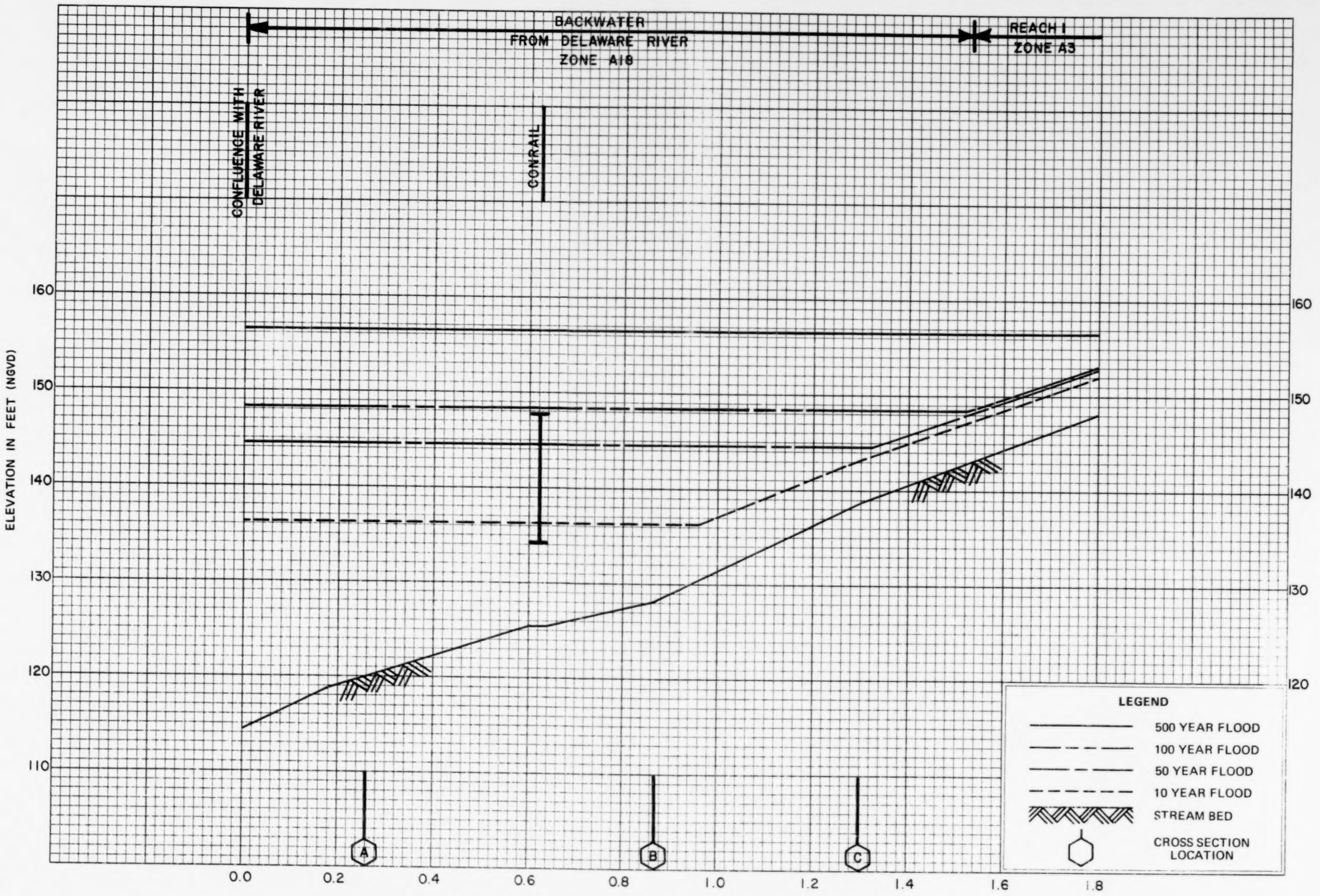

FLOOD PROFILES

TRIBUTARY NO.1 TO DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

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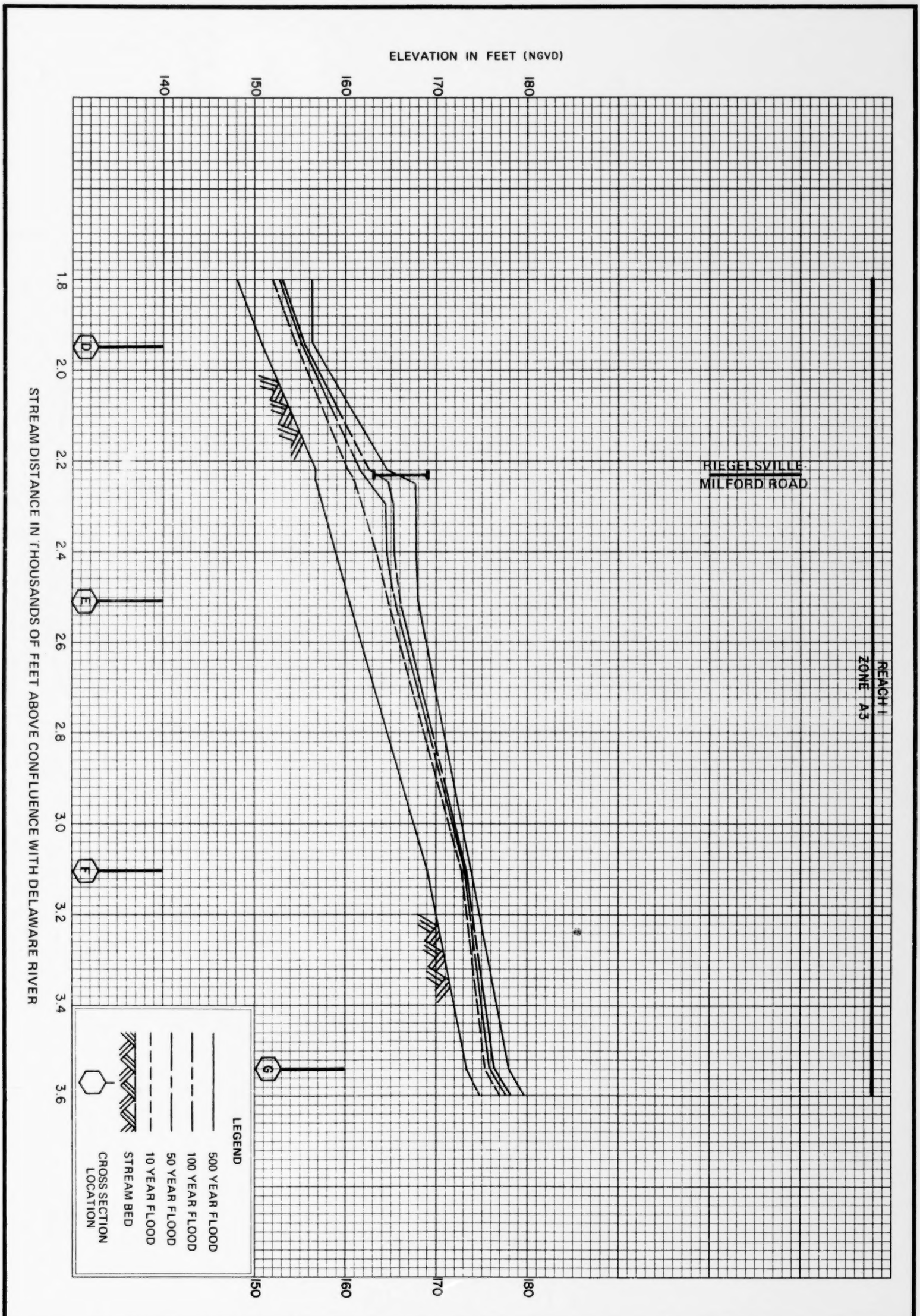

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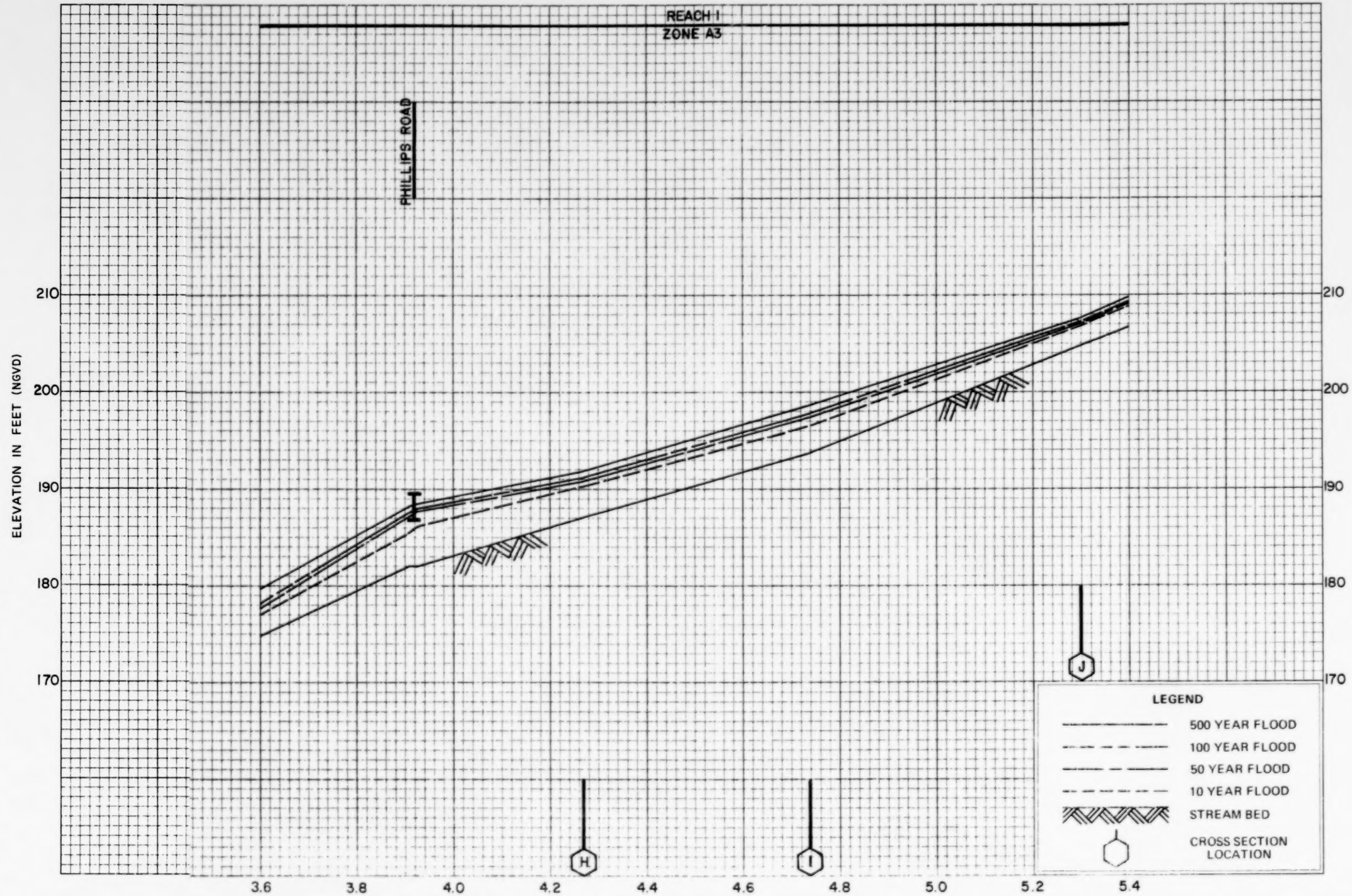
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOOD PROFILES

TRIBUTARY NO. I TO DELAWARE RIVER



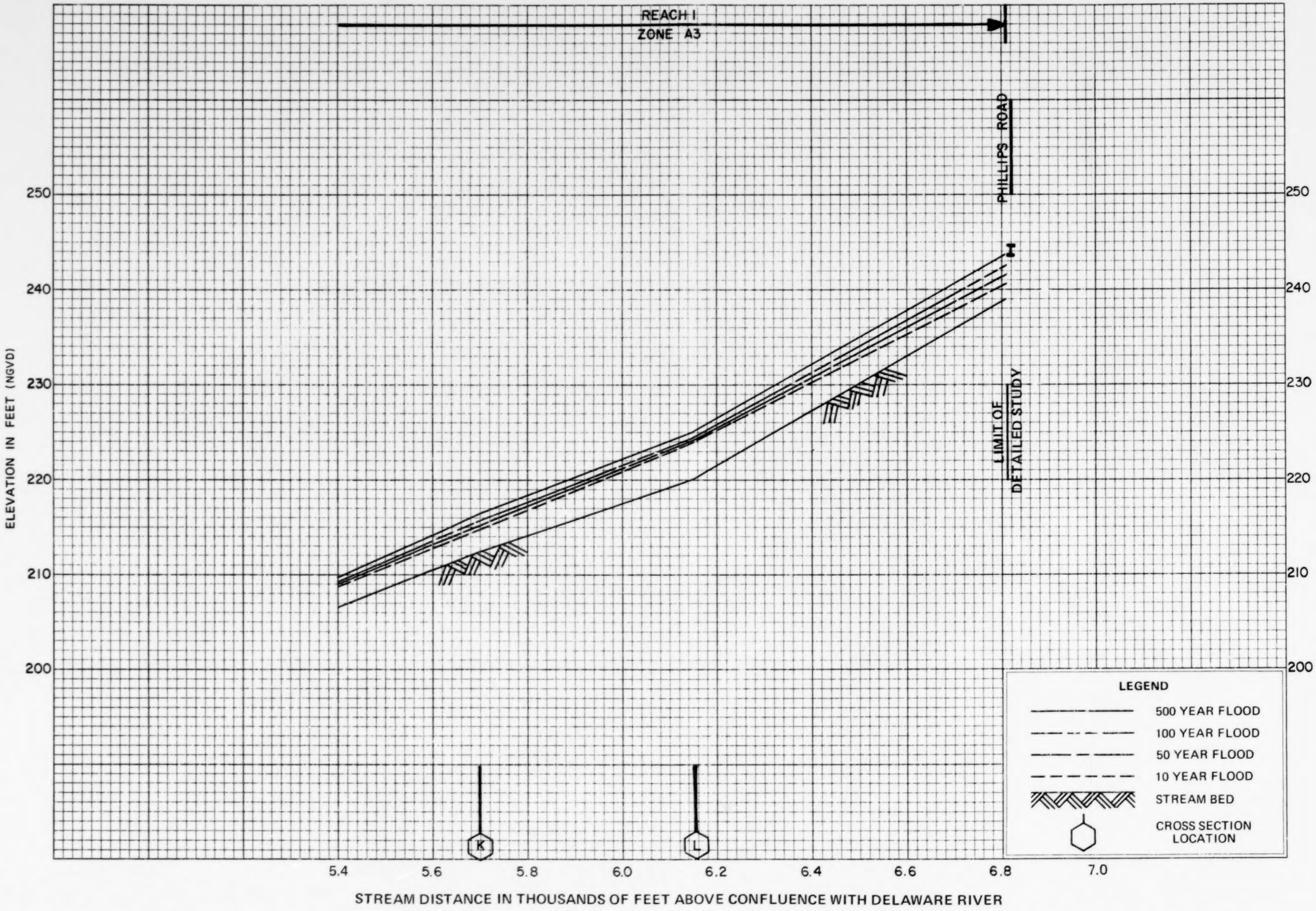
FLOOD PROFILES

TRIBUTARY NO. 1 TO DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

09P



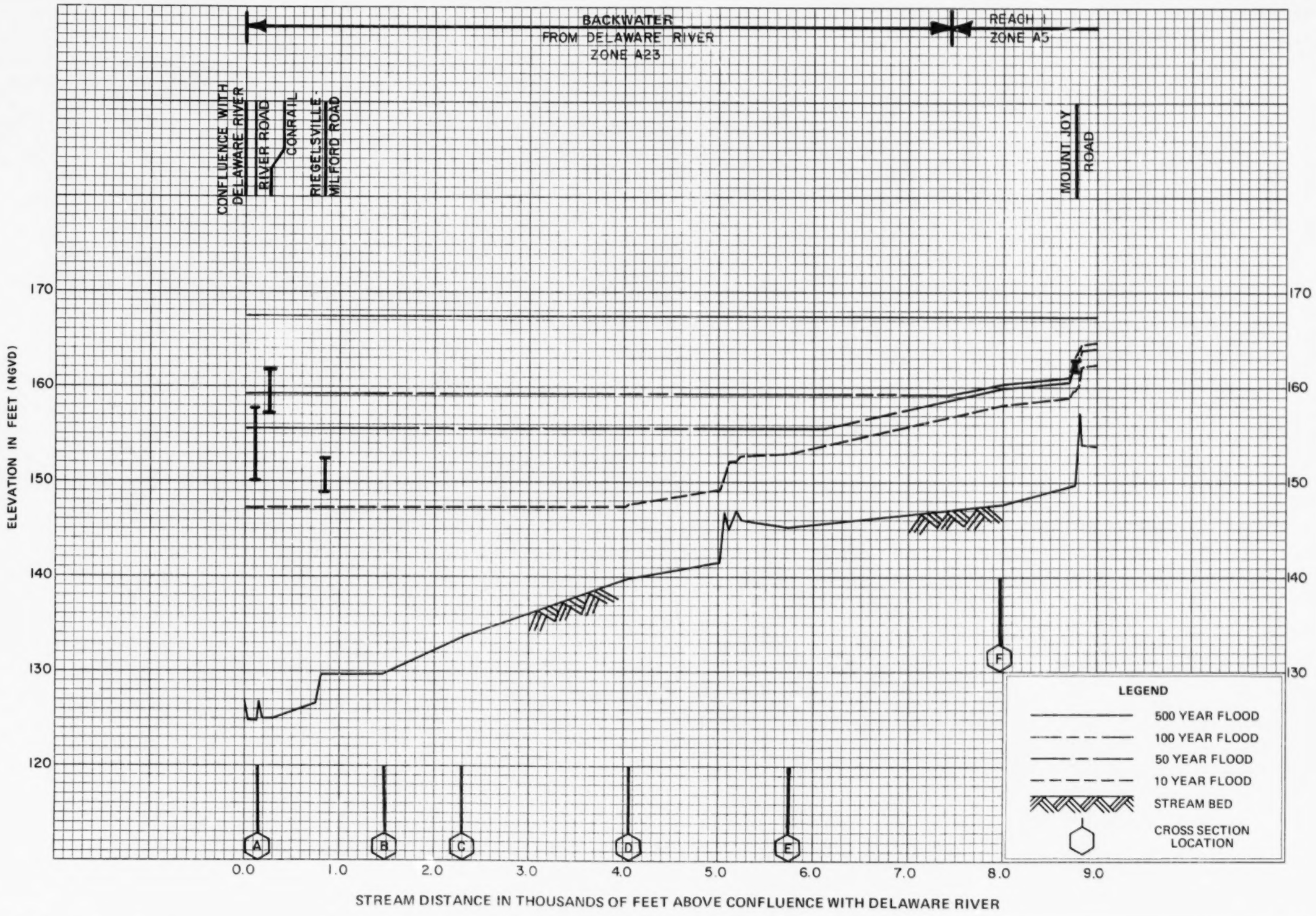
FLOOD PROFILES

TRIBUTARY NO.1 TO DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

10P



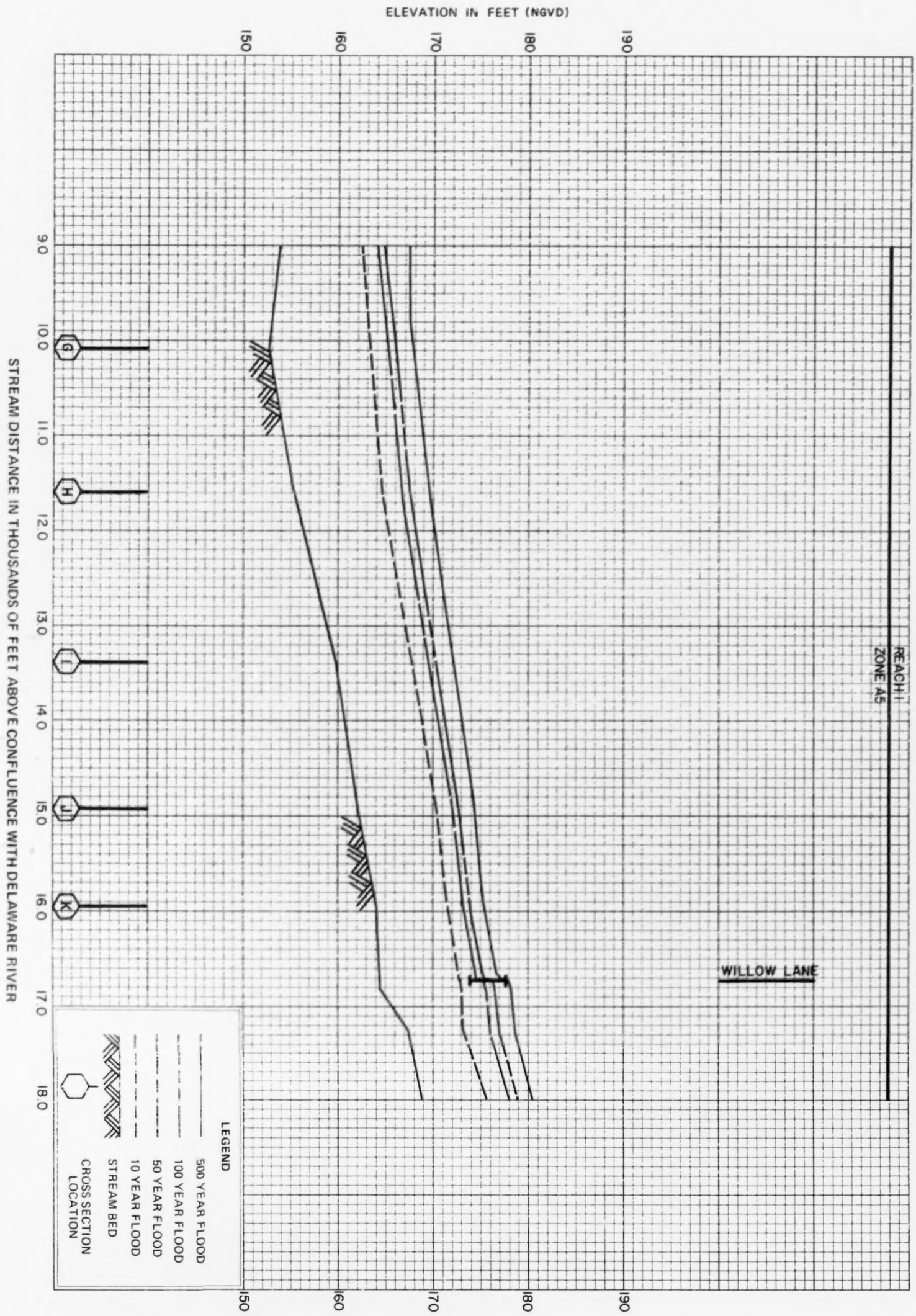
FLOOD PROFILES

MUSCONETCONG RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

11P



12P

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

FLOOD PROFILES

MUSCONETCONG RIVER

REACH 1
ZONE A5

DAM
MILFORD-WARREN GLEN ROAD
FOOTBRIDGE
PRIVATE ROAD

ELEVATION IN FEET (NGVD)

220
210
200
190
180
170
160

L
M
N

18.0 19.0 20.0 21.0 22.0 23.0 24.0 25.0 26.0 27.0

STREAM DISTANCE IN THOUSANDS OF FEET ABOVE CONFLUENCE WITH DELAWARE RIVER

LEGEND

- 500 YEAR FLOOD
- 100 YEAR FLOOD
- 50 YEAR FLOOD
- 10 YEAR FLOOD
- STREAM BED
- CROSS SECTION LOCATION

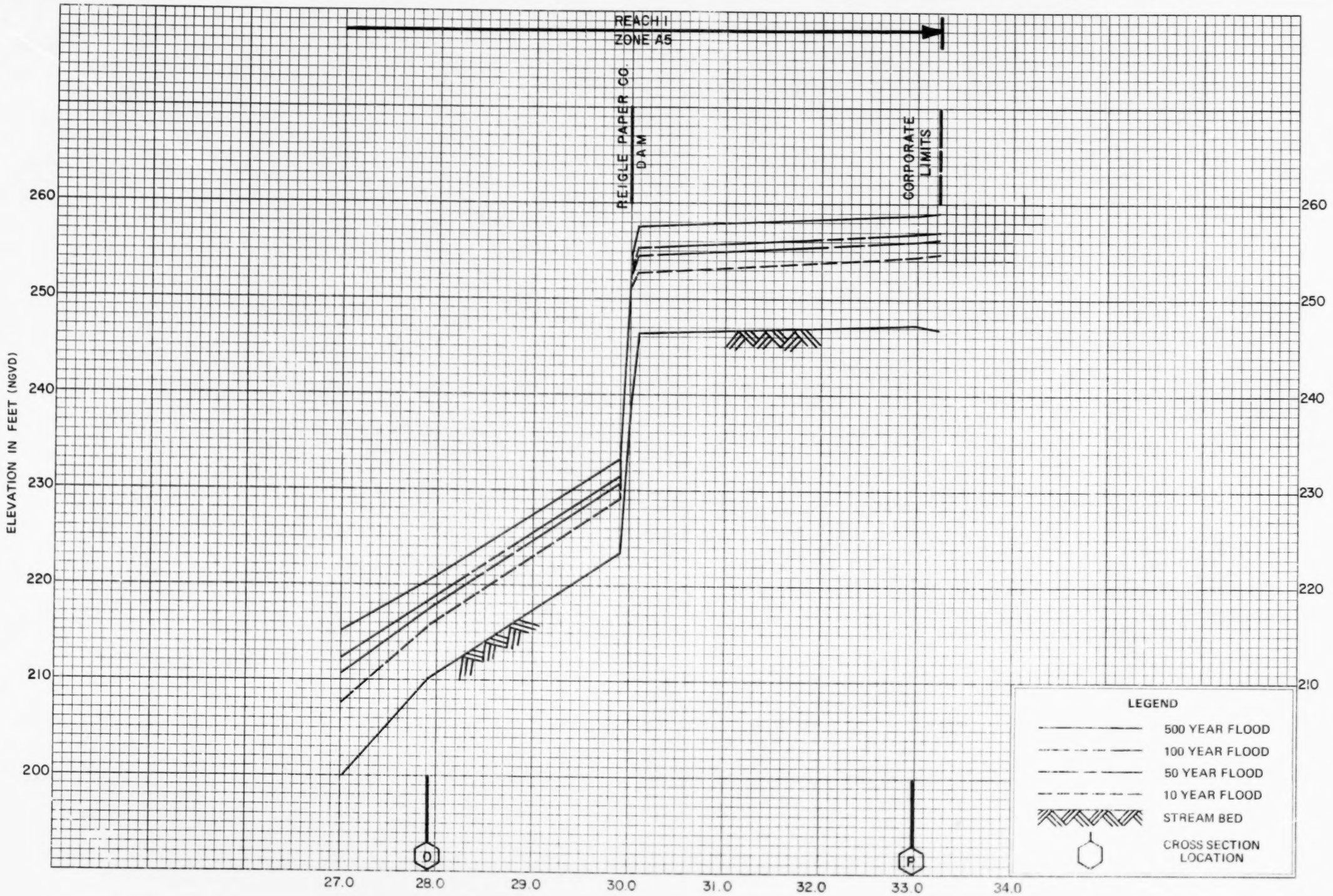
FLOOD PROFILES

MUSCONETCONG RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

13P



FLOOD PROFILES

MUSCONETCONG RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWNSHIP OF HOLLAND, NJ
(HUNTERDON CO.)

14P